SEPARATING SEMICONDUCTOR DEVICES FROM SUBSTRATE BY ETCHING GRADED COMPOSITION RELEASE LAYER DISPOSED BETWEEN SEMICONDUCTOR DEVICES AND SUBSTRATE INCLUDING FORMING PROTUBERANCES THAT REDUCE STICTION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This is a continuation-in-part application of pending U.S. patent application Ser. No. 13/707,875 filed Dec. 7, 2012, which is a divisional application of U.S. patent application Ser. No. 12/957,082 filed Nov. 30, 2010, issued on Dec. 11, 2012 as U.S. Pat. No. 8,329,503, which is a continuation-in-part of pending U.S. patent application Ser. No. 11/933,458 filed Nov. 1, 2007. The entireties of these applications are incorporated herein by reference.

STATEMENT OF GOVERNMENT RICHES

[0002] This invention was developed under Contract DE-AC04-94AL85000 between Sandia Corporation and the U.S. Department of Energy. The U.S. Government has certain rights in this invention.

FIELD

[0003] Embodiments described herein generally relate to semiconductor processing. In particular, embodiments described herein generally relate to methods and apparatus for separating semiconductor devices from a substrate.

BACKGROUND

[0004] Photovoltaics refers to a technology for converting solar radiation or other forms of light into electricity. The electricity generated through photovoltaics may be used for various different purposes, such as, for example, to power electrical devices or systems, provide electricity to an electrical grid, or recharge batteries or otherwise store power. Photovoltaics may offer various potential advantages depending on the implementation. For one thing, photovoltaics is generally able to provide a relatively sustainable and/or renewable supply of energy. Additionally, photovoltaics generally tends to produce low to no pollution during use. Furthermore, photovoltaics may be used to provide electricity (e.g., to an electrical device, battery, etc.) in environments where such electricity is not otherwise necessarily readily available (e.g., mobile devices, remote locations). Additionally, photovoltaics are often able to provide a lightweight power source.

[0005] Photovoltaic cells or photovoltaic devices generally represent devices that are able to convert the solar radiation or other forms of light into electricity based on the photovoltaic effect. The photovoltaic cells are sometimes referred to in the arts as solar cells. The photovoltaic cells arc commonly made from various different types of semiconductor materials. Some photovoltaic cells are made from silicon based materials. Other photovoltaic cells are made from group III-V compound semiconductor based materials. Still other photovoltaic cells are made from various other types of materials. Different materials are commonly used for different reasons. For example, the silicon based materials generally offer the advantages of lower cost and/or a wider and more extensively developed set of fabrication technologies. Group III-V compound semiconductor based materials generally tend to be more costly, but often offer greater photovoltaic efficiencies.

[0006] In some applications, small and thin photovoltaic cells may offer advantages. Representatively, the small photovoltaic cells may have lateral dimensions on the order of several millimeters or less, and thicknesses on the order of several hundred micrometers or less. Such small and thin photovoltaic cells may be formed from reduced amounts of materials, which tends to decrease their manufacturing costs. Additionally, such small and thin photovoltaic cells may tend to have higher efficiencies, for example, due to reduced likelihood that they contain performance limiting features (e.g., point defects).

[0007] However, one challenge encountered when manufacturing such small and thin photovoltaic cells is that it tends to be more difficult to handle them and/or assemble them into photovoltaic modules, electronic devices, or other assemblies. Similar challenges present themselves when manufacturing other types of small and thin semiconductor devices.

SUMMARY

[0008] In one aspect, a method may include etching a release layer that is coupled between a plurality of semiconductor devices and a substrate with an etch. The etching may include etching the release layer between the semiconductor devices and the substrate until the semiconductor devices are at least substantially released from the substrate. In some embodiments, the release layer may optionally be a graded composition release layer. The etching may also include etching a protuberance in the release layer between each of the semiconductor devices and the substrate. The etch may be stopped while the protuberances remain between each of the semiconductor devices and the substrate. The method may also include separating the semiconductor devices from the substrate.

[0009] An apparatus of an aspect includes a substrate, a plurality of semiconductor devices over the substrate. The semiconductor devices may be substantially released from the substrate. The apparatus also includes a protuberance between each of the semiconductor devices and the substrate. In some embodiments, the protuberances may optionally have a graded composition.

[0010] A method of another aspect includes coupling a first receiving substrate with a first subset of semiconductor devices. Each of the semiconductor devices of the first subset may be disposed over a substrate with a corresponding, protuberance disposed between the semiconductor device of the first subset and the substrate. The first receiving substrate and the first subset of the semiconductor devices may be separated from the substrate. A second receiving substrate may be coupled with a second subset of the semiconductor devices. Each of the semiconductor devices of the second subset may be disposed over the substrate with a corresponding protuberance disposed between the semiconductor device of the second subset and the substrate. The second receiving substrate and the second subset of the semiconductor devices may be separated from the substrate.

[0011] The above summary does not include an exhaustive list of all aspects of embodiments of the invention. It is contemplated that embodiments may include all systems and methods that may be practiced from all suitable combinations of the various aspects summarized above, as well as those